# Intervention INC: Interactive Nutrition Comics for Urban Minority Youth

**Principal Investigator and Team Members.**
Principal Investigator: May May Leung, PhD, RDN
Co-Investigators: Tracy Dennis-Tiwary, PhD and Katarzyna Wyka, PhD
Project Manager: Katrina F. Mateo, MPH
Lead Research Assistant: Sandra Verdaguer, MSc, MPH
Team of Research Assistants (28 over course of grant period)
Team of Comic Artists and Software Designers (5 over course of grant period)
Extensive network of collaborators and content experts (providing guidance over grant period)

**Organization.**
Primary: Hunter College, City University of New York
Collaborators: Children's Aid & Weill Cornell Medical College

**Inclusive Dates of Project.**
Original: April 1, 2016 to April 1, 2018
No cost extension: Through September 30, 2018

**Federal Project Officer.**
Derrick Wyatt, MSN, RN-BC, CPHIMS, CMCN

# TABLE OF CONTENTS

# Abstract

**PURPOSE:** To design and develop a human-centered, interactive, narrative-based internet/mobile-enabled dietary self-management intervention focused on reducing childhood obesity risk in Black/African American (AA) and Latino children ages 9 to 12 years.

**SCOPE:** Childhood obesity is a serious clinical and public health challenge, particularly among low-income, minority populations. Effective, yet innovative interventions are needed to capture the attention of children living in a media-saturated environment. As the pervasiveness of technology/media use continues to expand, potential opportunities emerge to deliver web-based and mobile health (mHealth) interventions.

**METHODS:** Three phase study design – formative, development, and evaluation phase (2-group randomized study) – with urban minority children and their parents utilizing user-centered approaches (focus groups/interviews, co-designing, and usability testing, piloting).

**RESULTS:** In the **formative phase**, children and parents identified priority health behaviors, barriers to healthy eating, and other social/environmental factors influencing obesity-related dietary behaviors. During the iterative **development phase**, children and parents overall responded positively to initial concepts, designs, and content. Key suggestions/feedback contributed to subsequent changes and iterations. In the **evaluation phase**, preliminary results were promising; usability, feasibility and acceptability of the tool was confirmed. Thus, we will pursue the development of a full-scale randomized controlled trial to test the tool's effectiveness.

**Key Words:** mHealth, childhood obesity, minority, diet

# Purpose

The purpose of this study was to conduct a pilot and feasibility study aimed at designing and developing a human-centered, interactive, narrative-based internet/mobile-enabled dietary self-management intervention focused on reducing childhood obesity risk. Using an innovative, narrative-based approach, it was tailored to the needs and preferences of low-income, minority children ages 9 to 12, to enhance its adoption and use for this priority population.

# Scope

Childhood obesity continues to be a serious clinical and public health challenge. In the United States (US), obesity prevalence among children ages two to 19 is 18.5%, with low-income, minority populations such as Latino and Black/African-American (AA) children having the highest rates at 25.8% and 22.0%, respectively (1). This epidemic has profound short- and long-term consequences as it not only leads to negative health outcomes, such as type 2 diabetes and cardiovascular disease, but also increases risk of adult morbidity and mortality (2–5). This complex epidemic has been associated with high consumption of energy-dense foods and sugary drinks, as well as low consumption of nutrient-dense fruits and vegetables (F/V) (6–8).

Effective, yet innovative interventions are needed to capture the attention of children living in a media-saturated environment. Interventions incorporating visual narratives like comics, may engage today's youth around health topics and promote positive psychosocial and behavioral outcomes (9–11). Moreover, narrative-based health communication interventions can be particularly effective in populations with strong storytelling traditions such Latino and Black/AA communities (12,13).
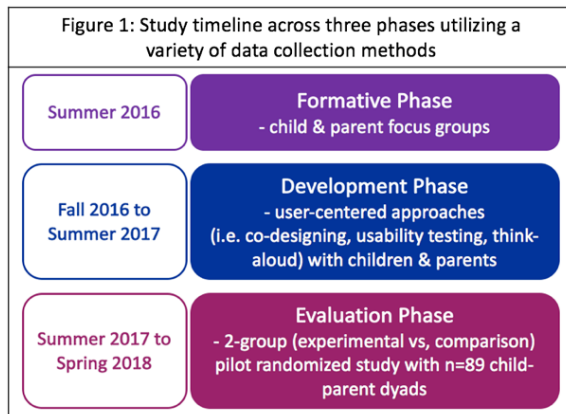
As the pervasiveness of technology/media use continues to expand within the Latino/ Black youth population (14–16), potential opportunities and new avenues emerge to deliver web-based and mobile health (mHealth) interventions. Technology-based interventions focused on dietary behavior change can allow users to engage with culturally-relevant and adaptive/tailored health information on their own time, at their own pace, and in their preferred place/environment (17–19).

In this study, we successfully generated new knowledge related to multiple research areas of interest for AHRQ, including design, development, implementation, usability and use of health information technology (IT), for culturally diverse and hard-to-reach populations at greatest risk for childhood obesity by accomplishing the following aims:

- Aim 1: Conduct focus groups to identify the perceived individual, social, and environmental factors that influence children's obesity-related dietary behaviors among low-income, minority, inner-city children ages 9 to 12 and their parents/caregivers.
- Aim 2: Guided by a theoretical framework and formative research from Aim 1, design and develop an interactive, internet/mobile-enabled intervention promoting dietary self-management focused on reducing childhood obesity risk among low-income, minority, inner-city children ages 9 to 12.
- Aim 3: Using a two-group pilot randomized study design:
    - 3.1. Assess the feasibility and participant acceptability of the pilot interactive, internet/mobile-enabled dietary self-management intervention.
    - 3.2. Explore if the interactive, internet/mobile-enabled intervention improves knowledge, attitudes, and food preferences associated with the targeted behaviors to reduce childhood obesity risk, from baseline to post-test.

# Methods

## Overview



Figure 1: Study timeline across three phases utilizing a variety of data collection methods

**Summer 2016** — Formative Phase - child & parent focus groups

**Fall 2016 to Summer 2017** — Development Phase - user-centered approaches (i.e. co-designing, usability testing, think-aloud) with children & parents

**Summer 2017 to Spring 2018** — Evaluation Phase - 2-group (experimental vs. comparison) pilot randomized study with n=89 child-parent dyads

In partnership with a community-based organization (CBO) and an interdisciplinary intervention development team (comprising a story writer, comic artists, computer programmer, graphic designer, entertainment-education animation experts, (voice) actors, and academics (professors, researchers, and students) specializing in health communication, nutrition, psychology, and technology-based interventions), this study was completed over three phases - formative, development, and evaluation - with each phase accomplishing one of the three study aims. **Figure 1** shows an overview of the study timeline, as well as key methods used in each phase. Child assent, parental permission, and/or adult consent were obtained prior to the start of any study procedures. All study procedures were approved by the City University of New York (CUNY) Institutional Review Board.

## Aim 1 (Formative Phase)

### Study Design

During the formative phase, child-/parent-only focus groups and child-parent dyad interviews were conducted with low-income urban Latino and Black/AA children and their parents around the topics of dietary behaviors, technology use, narrative concepts, and other proposed intervention components.

### Participants

Participants were recruited from a child-focused CBO, whose mission is to help children in poverty succeed and thrive in high-needs New York City (NYC) neighborhoods. Child eligibility criteria consisted of: the child being between the ages of 9 and 12, Latino and/or Black/AA, English-speaking, having internet access, as well as access to a smartphone or tablet. Parent eligibility criteria consisted of a parent: with a child between the ages of 9 and 12 years, self-identifying as Latino and/or Black/AA, being English- or Spanish-speaking, having internet access via smartphone or tablet, and having an interest in talking about food and technology. Each participating child and parent received a $10 gift card and a round-trip MetroCard ($5.50 value) to cover travel to and from the study site.

### Data Sources/Collection/Analysis

Data collection occurred in July and August 2016 at three CBO sites. Participants chose to participate in either a child-/parent-only focus group or a parent-child dyad interview. Dyad interviews were conducted with the intent of identifying parent-child interactions relevant for intervention design. Once arriving at their scheduled study session, children/parents completed a

paper survey focused on demographics, food purchasing/preparation roles, phone/tablet ownership, and technology use, followed by a focus group/interview session, moderated by a trained research team member. Bilingual team members moderated interviews with Spanish-speaking parents. Semi-structured guides were created and utilized to assist the moderator in discussing key topics with participants to inform intervention design and content. In addition to field notes taken by a trained note-taker, each session was audio-recorded. The research team met weekly to review study sessions and determined whether data saturation was reached (when data collection failed to elicit new information relevant to intervention design).

Four child focus groups were conducted with a range of five to nine participants (n=25, 19 females). On average, each focus group lasted 49 minutes. Three parent-only focus groups were conducted with a range of three to five participants each (n=13 parents). On average, each parent focus group lasted 54 minutes (range: 50-56 minutes). Seven parent-child dyad interviews (n=7 parents; n=7 children) were conducted (two conducted with a bilingual moderator, speaking in English with the child and in Spanish with the parent). On average, each dyad interview lasted 35 minutes (range: 26-52 minutes).

*Data Analysis.* Descriptive analyses were run on survey data to calculate frequencies and percentages. Audio files from focus groups and interviews were translated and/or transcribed verbatim and uploaded into Dedoose software (Version 7.6.6) to facilitate data analysis and coding. Inductive and deductive approaches were utilized in the qualitative analysis process to identify key patterns and themes to guide intervention development.

# Aim 2 (Development Phase)

## Study Design

Multiple study sessions that included iterative design activities (content confirmation, co-designing, and usability testing of prototypes) were conducted to ultimately produce a culturally-relevant interactive nutrition comic and website for youth, as well as web-based health newsletters to support healthy parental feeding behaviors and the home food environment.

## Participants

Participants from the formative phase (Aim 1) were invited to participate in development phase study sessions. Incentives for participation ranged from $10 (participating in comic/newsletter/website content confirmation or usability testing) to $15 (participating in prototype assessments or co-designing). All participants also received a round-trip MetroCard ($5.50 value) to cover travel to and from the study site (either a CBO site or the main study site)

## Data Sources/Collection/Analysis

Multiple activities and sessions were conducted between Fall 2016 and Summer 2017 during the development phase, which are noted below.

*Content Confirmation (October 2016).* Children were invited to provide feedback and help further develop the proposed comic story and characters, which were initially developed by the interdisciplinary design team based on formative research findings. Two audio-recorded focus groups were conducted (n=6), lasting approximately 60 minutes each. A trained team member moderated, following a semi-structured interview guide and PowerPoint presentation to provide visuals.

Parents completed a brief paper survey to identify preferences for parent-focused health content delivered via a web-based health promotion tool (e.g. recipes, coupons, healthy eating tips, local sales, local farmers markets, nutrition education, local/community events promoting health and wellness), as well as assess preferred format and frequency of content delivery (n=6).

*Content Prioritization (November 2016).* Children were invited to guide decision-making around the tool platform and reminder message delivery approach, as well as further develop comic details and health-promoting content that would be delivered by the comic characters. One audio-recorded focus group was conducted (n=4) lasting 51 minutes. A trained team member moderated, following a semi-structured interview guide and PowerPoint presentation to provide visuals.

Parents were invited to participate in a study session to discuss: 1) preferences for text or email messages to motivate them to click on a link to access parent-focused health information, 2) behaviors around food shopping, and 3) approaches to communicating/motivating their child. For each session, a trained team member moderated and audio-recorded each interview following a semi-structured interview guide. Two parent interviews were conducted (two other available parents declined to participate), one lasting 47 minutes (conducted in English) and the other lasting 43 minutes (conducted in Spanish).

*Tool/Website Development (January 2017).* Children were invited to review chapter one (print-version) of the comic and participate in co-designing approaches to develop and discuss website wireframe and design ideas, on which the comic would be housed. Two audio-recorded focus groups were conducted (n=6), which lasted 67 and 78 minutes, respectively. A trained team member moderated, following a semi-structured interview guide and PowerPoint presentation to provide visuals.

Parents were invited to participate in a study session using co-designing approaches to develop and confirm aspects of the parent tool. Specifically, a presentation deck and interview guide was designed to walk parents through: 1) sample images of text messages parents would receive with a link to access parent-focused health information, 2) a wireframe of the parent tool homepage, and 3) sample content for each section of the parent homepage (i.e., healthy eating tips, tips for parent-child social interaction around healthy eating, recipes, coupons/sales, resources/events). A trained team member moderated and audio-recorded each session. Two parent focus groups were conducted in English (n=4), one lasting 54 minutes and the other lasting 96 minutes.

*Tool/Website Development (April 2017).* Children were invited to participate in a session to review chapter two (digital, non-interactive version) and provide feedback to guide content for the goal-setting component. Three one-on-one interviews were conducted (n=3. A trained team member moderated each interview, following a semi-structured interview guide.

*Usability Testing (March, June, July 2017).* Children were invited to participate in several rounds of one-on-one usability testing of different interactive versions of comic chapters, which occurred in March (n=8), June and July 2017 (n=8). The website (where the comic was housed) was also tested in June/July 2017. Usability testing is a critical step in development to ensure technology tools are understandable and useful for end-users (20,21). A trained team member moderated and audio-recorded each session, following a guide with examples of prompts to encourage verbalized feedback. An additional team member took notes, recording non-verbal reactions and behaviors. Each session comprised a brief think-aloud training (22) and usability testing of each interactive chapter. Additional procedure details from June/July 2017 are published elsewhere (23).
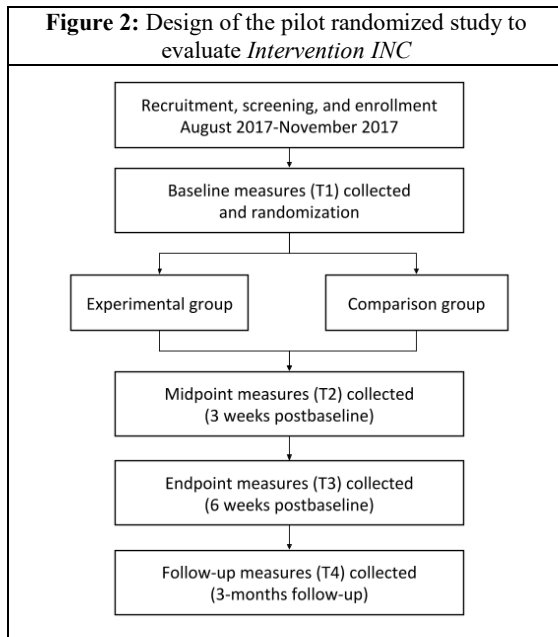
In June and July 2017, parents were invited to participate in one-on-one usability testing of the web-based tool (n=9; 3 Spanish-speaking). Different aspects of the tool were assessed (text/email messages, login process, and newsletter of week one, two and three). At each session, a trained team member moderated, while an additional team member took notes, recording non-verbal reactions and behaviors. Each session comprised of a brief think-aloud training, audio-recorded usability testing of

the web-based tool components with a think-aloud protocol and moderator guide (with examples of prompts to encourage verbalized feedback from participants throughout testing), and a paper survey to assess nine usability and acceptability questions using a 5-point Likert-type response scale.

*Data Analysis.* Descriptive analyses were run on survey data to calculate frequencies and percentages. Audio files and field notes from study sessions were systematically reviewed on an ongoing basis as team members extracted key feedback (e.g. likes, dislikes, wants, gaps, points of confusion, etc.) to guide iterative intervention development.

# Aim 3 (Evaluation Phase)

## Study Design

**Figure 2:** Design of the pilot randomized study to evaluate *Intervention INC*

Recruitment, screening, and enrollment
August 2017-November 2017

Baseline measures (T1) collected
and randomization

Experimental group

Comparison group

Midpoint measures (T2) collected
(3 weeks postbaseline)

Endpoint measures (T3) collected
(6 weeks postbaseline)

Follow-up measures (T4) collected
(3-months follow-up)

Once the web-based tool (including both child- and parent-focused components) was developed, a pilot, single-blind, 2-group randomized study was conducted to evaluate it, which was implemented as a 6-week intervention, with a 3-month follow-up period (see **Figure 2**). Child-parent dyads were enrolled into the study on a rolling basis between August and November 2017. Dyads were randomized to either the experimental group, in which the child received a Web-based comic with health messages primarily promoting either fruit/vegetable (F/V) or water consumption or the comparison group, in which the child received Web-based newsletters with health information similarly promoting primarily F/V or water consumption. Parents of both groups received Web-based health newsletters; however, parents in the experimental group were also given access to the child comic. Dyads were blinded to group assignment. Data were collected at 4 different time points: baseline (T1), intervention midpoint or 3 weeks post-baseline (T2), intervention endpoint or 6 weeks post-baseline (T3), and 3-month follow-up post-intervention (T4). The protocol for this study was registered with the Clinical Trials Registry (NCT03165474) and published in a manuscript (25).

## Participants

Children residing in NYC were recruited based on the following inclusion/exclusion criteria: self-identifies as black/African American and/or Latino; aged between 9 and 12 years (preadolescents) at the time of scheduled baseline visit, reads and speaks in English; has a body mass index (BMI) percentile at or above 5% at baseline (categorized as healthy, overweight, or obese); has regular internet access via a tablet device, mobile phone or computer/laptop; has regular access to a phone with texting capability; is comfortable reading/viewing material on electronic devices; is comfortable speaking with study staff about thoughts/experiences while participating in the study; has no allergies, food aversions, food disorders, or medications with side-effects that may impact participation in the study; does not have a pacemaker or heart condition; and has a legal parent/guardian willing to participate in the study.

Parents/guardians were recruited based on the following inclusion/exclusion criteria: legal parent/guardian of child willing to participate in the study; reads and speaks in English or Spanish;

primarily responsible for preparing/purchasing food for child; has regular internet access via a tablet device, smartphone, or computer/laptop; has regular access to a phone with text messaging capability; comfortable reading/viewing material on electronic devices; and able to attend in-person study visits and complete online questionnaires with their child over the full duration of the study.

Several recruitment approaches (with bilingual materials) were utilized to enroll child-parent dyads. Recruitment letters were sent to the parent/guardian of eligible child patients (based on age, race/ethnicity, and BMI percentile criteria) who had received care at a community-based clinic (partnering organization) in upper Manhattan, NYC, within the last 2 years. Recruitment approaches also included local community flyering in East Harlem/Upper Manhattan, posting inside/near local businesses, housing complexes, community centers, schools, and churches. Through several partnerships with local schools and community initiatives, recruitment efforts also occurred via tabling at community and school events.

Interested parents/guardians had the option to call, text, or email study staff to receive more information about the study. Those receiving recruitment letters also received a recruitment call to assess interest in the study and receive additional information. Interested parents/guardians completed a screening form via phone/email to determine study eligibility. Eligible participants were scheduled to attend a baseline (T1) visit where the child's height and weight were measured to determine if the final eligibility criteria for BMI percentile was met (at or above 5%).

To minimize attrition, child participants were compensated up to US $70 in gift cards and parent/guardian participants up to US $65 for completing data collection. Compensation was distributed in increasing amounts at each time point (T1: child US $10, parent/guardian US $15; T2: child US $15; T3: child US $20, parent/guardian US $20; and T4: child US $25, parent/guardian US $30). Each participant had the option to select a gift card from either a large department store retailer, a discount supermarket chain, a supermarket chain specializing in selling organic products, or a sporting goods retailer. Participants also received a round-trip MetroCard for any in-person study visits. If a dyad completed data collection at all 4 time points, they were entered into a raffle for a US $100 gift card.

## Intervention

The web-based tool, called *Intervention INC*, was underpinned by several theories, including the Narrative Transportation Theory, Social Cognitive Theory, Health Belief Model, and Parenting Styles/Feeding constructs. The **child component** consisted of a 6-chapter interactive nutrition comic optimized for use on tablet devices, a goal-setting and self-assessment feature, and weekly text/email messages and reminders. The **parent component** consisted of 6 web-based newsletters, access to the child comic, and weekly text/email messages and reminders. **Figure 3** depicts the conceptual framework of *Intervention INC* and **Figures 4-7** depict screenshots of intervention content (comic, newsletter, goal setting component, text messages) for the child and parent participants in the experimental and comparison groups. A more detailed description of the intervention is available in a published manuscript (25).

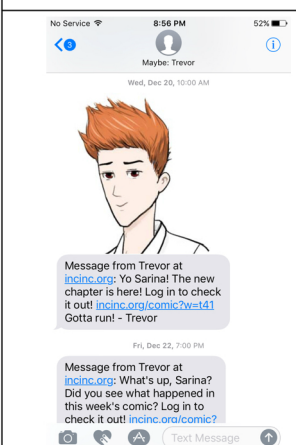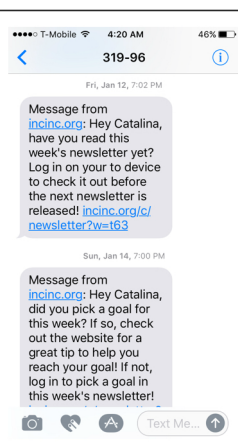**Figure 3:** Conceptual framework of *Intervention INC*
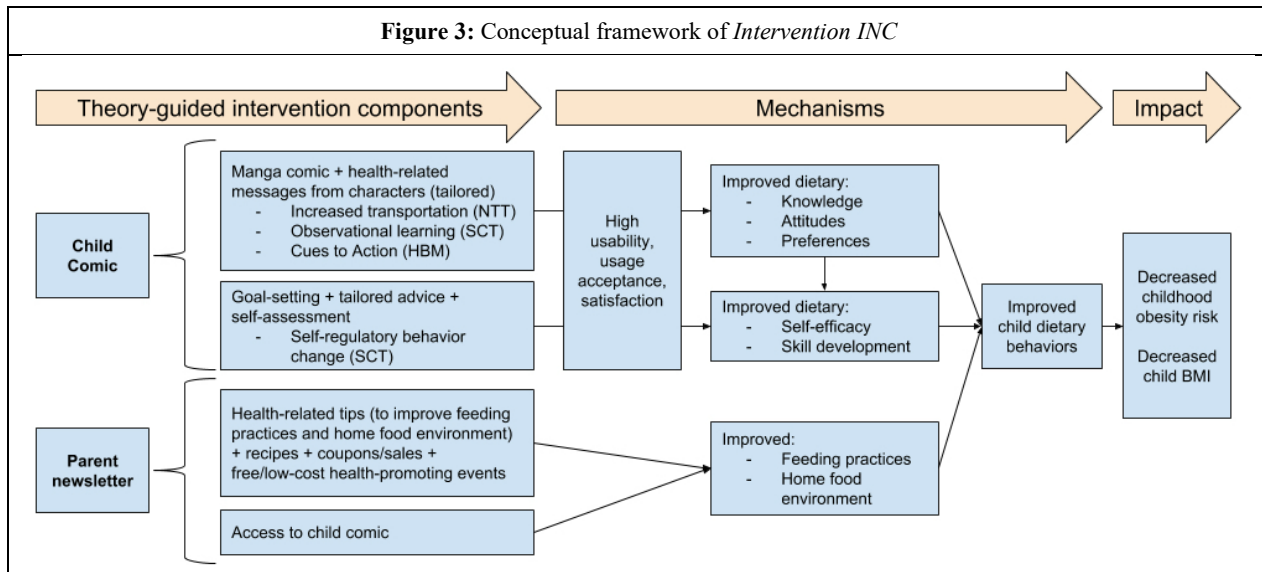


**Figure 4:** Screenshots of the child experimental group (web-based comic) versus comparison group content (web-based newsletter)
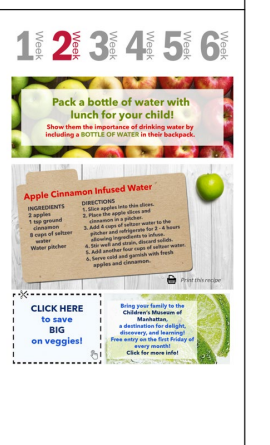
*Experimental group content* | *Comparison group content*
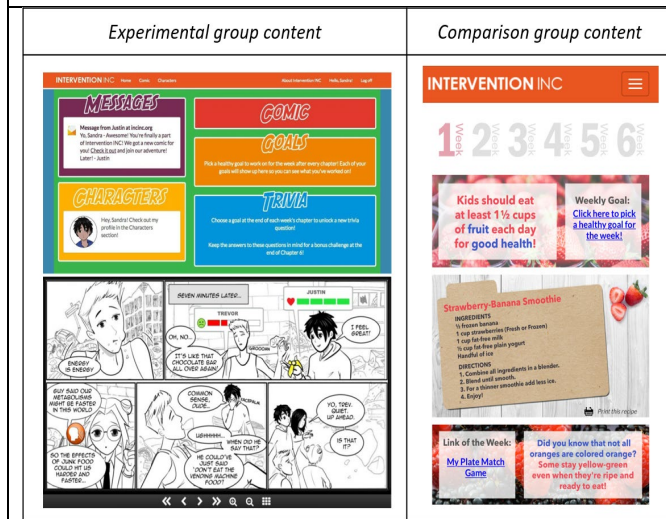
**Figure 5:** Screenshots of the child experimental group versus comparison group goal-setting component

*Experimental group content*

*Comparison group content*
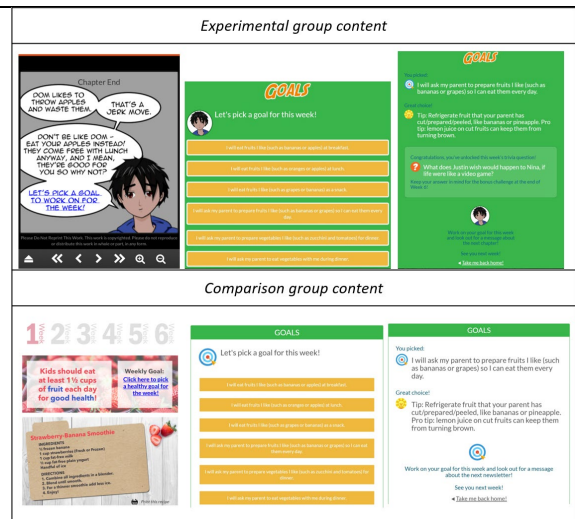
**Figure 6:** Screenshots of text messages sent to children in the experimental group versus comparison group

**Figure 7:** Screenshots o the parent experimental group content versus the comparison group content

## Data Sources/Collection/Analysis

Primary measures comprised usage, usability, and feasibility of the web-based tool. Secondary measures comprised dietary knowledge, preferences, and intake and anthropometric measures (for child) and feeding practices and home food environment (for parent). **Table 1** is a summary of key measures and when these measures were collected.

| Measures | Data Source | Time points | | | | |
|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 | O |
| **Table 1:** Aim 3 Key Measures, Data Source, and Time of Assessment | | | | | | |
| *Feasibility/acceptability measures (primary measures)* | | | | | | |
| Usage of web-based tool | Tracking system [internally created] | | | | | C/P |
| Usability of web-based tool | Interview, Questionnaire Items | | C | C/P | C/P | |
| Study implementation feasibility | Process data (e.g. recruitment, attrition) | | | | C/P | S |
| *Outcome measures (secondary measures)* | | | | | | |
| Dietary Knowledge & Attitudes | Questionnaire Items | C | C | C | C | |
| Dietary Intake | Questionnaire Items | C | C | C | C | |
| Anthropometric Measures | Digital Stadiometer, Body Composition Monitor | C | | | C | |
| Feeding Practices | Questionnaire Items | P | | P | P | |
| Home Food Environment | Questionnaire Items | P | | P | P | |
| Time points indicated by T1=Baseline, T2=Midpoint (3 weeks post-baseline), T3=Endpoint (6 weeks post-baseline), T4=Follow-up (3 months post- intervention), O=Ongoing throughout intervention period. Data collected either from C=child, P=parent/guardian, S=study staff (internal). | | | | | | |

*Quantitative Data Analysis.* Usage and usability of the web-based tool, along with the feasibility of study implementation, was assessed using descriptive analyses. Changes in study outcomes within and between groups were examined using mixed-models methodology with repeated assessments (T1, T2, T3, and T4), condition (experimental / comparison), and time by condition interaction. Both within- and between-group effect sizes were calculated for all study measures to assess the magnitude of intervention effects overall and by potential moderators and inform subsequent larger randomized controlled studies.

*Qualitative Data Analysis.* Audio files of interviews conducted with children and parents/guardians at T2, T3, and T4 were systematically reviewed using inductive and deductive processes to identify trends and recurring themes, especially related to barriers and facilitators to use and adoption of the *Intervention INC* tool.

# Results

## Aim 1 & 2 (Formative and Development Phases)

### Participants

**Tables 2** and **3** summarize the demographics of the child and parent study participants in the first two phases of our study.

| **Table 2:** Demographics of child study participants and study participation in the formative and development phases | | |
|---|---|---|
| | **Formative Phase (n=32)** | **Development Phase (n=21) [a]** |
| **Gender** | | |
| Female | 19 (59%) | 12 (57%) |
| Male | 13 (41%) | 9 (43%) |
| **Race/Ethnicity [b]** | | |
| Black/African-American | 20 (63%) | 12 (57%) |
| Hispanic/Latino | 19 (59%) | 11 (52%) |
| Other Race | 5 (16%) | 3 (14%) |
| **School Grade** | | |
| 4th | 10 (31%) | 4 (19%) |
| 5th | 8 (25%) | 4 (19%) |
| 6th | 8 (25%) | 7 (33%) |
| 7th | 4 (13%) | 3 (14%) |
| 8th | 2 (6%) | 3 (14%) |
| **Participation [c]** | | |
| 1 session | 32 (100%) | 13 (62%) |
| 2 sessions | - | 1 (5%) |
| 3 sessions | - | 4 (19%) |
| 4 sessions | - | 3 (14%) |
| Notes: <br> [a] 16 children from Formative Phase participated in Development Phase study sessions <br> [b] Children could select multiple race/ethnicities <br> [c] Some Development Phase participants took part in multiple study sessions | | |

| | Formative Phase (n=20) | Development Phase (n=15) [a] |
|---|---|---|
| **Table 3:** Demographics of parent study participants and study participation in the formative and development phases | | |
| **Gender** | | |
| Female | 19 (95%) | 13 (87%) |
| Male | 1 (5%) | 2 (13%) |
| **Race/Ethnicity** [b] | | |
| Black/African-American | 8 (40%) | 7 (47%) |
| Hispanic/Latino | 12 (60%) | 8 (53%) |
| Multiracial | 1 (5%) | - |
| **Age (years)** | | |
| <25 | 0 (0%) | 0 (0%) |
| 26-35 | 7 (35%) | 2 (14%) |
| 36-45 | 9 (55%) | 5 (36%) |
| 46-55 | 4 (20%) | 7 (50%) |
| 55+ | 0 (0%) | 0 (0%) |
| **Participation** [c] | | |
| 1 session | 20 (100%) | 10 (67%) |
| 2 sessions | - | 4 (27%) |
| 3 sessions | - | 1 (7%) |

Notes:
[a] 10 parents from Formative Phase participated in Development Phase study sessions; one parent did not give age
[b] Parents could select multiple race/ethnicities
[c] Some Development Phase participants took part in multiple study sessions

## Principal Findings & Outcomes

**Tables 4** and **5** include a summary of key findings from study sessions with child and parent participants and how they informed development of the web-based comic tool and parental newsletters.

## Limitations

While Aims 1 and 2 have many strengths, including an interdisciplinary design team, the use of user-centered approaches during the design process, and the integration of evidence-based and theory-guided health promotion content, there are several limitations that should be noted. With some data collection conducted in group settings, social desirability, social norms, and peer groups dynamics could have biased findings. The use of formative phase participants throughout the development phase may have also resulted in biases regarding preconceived ideas for how the web-based tool should look or how the comic storyline should be actualized. However, engaging the same participants throughout study phases builds on prior knowledge, which may have contributed to more relevant/informed feedback (29). While further testing and refinements should ideally be incorporated before tool dissemination in real-world settings, user-centered approaches used in this study were time-/resource-intensive, which limited the amount of formal testing that could be conducted. Finally, as the tool was developed specifically for urban, low-income Black/AA and Latino preadolescents and their parents, its generalizability is limited.

| Table 4: Summary of key findings from study sessions with child participants and applications to web-based tool development | | |
|---|---|---|
| **Phases** | **Key Findings** | **Application to Web-Based Child Tool** |
| Formative | | |
| Technology, Dietary Behaviors & Comic Concepts | • Preferred devices to access internet were smartphones and tablets<br>• Dietary behavior perceived to be most important was eating F/V<br>• Learn about health through friends, mothers, and cooking classes<br>• Preferred genres included suspense, sci-fi, action/adventure, and comedy<br>• Preferred character traits included kindness, generosity, and perseverance<br>• Preferred daily messages that are humorous and varied | • Tool is optimized for mobile devices, especially tablets<br>• Health content of comic tool focuses on eating F/V and drinking water<br>• Health education in comic is delivered by different comic characters<br>• Preferred genres were incorporated into storyline development<br>• Preferred traits were incorporated into main character's personality<br>• Varied reminder messages were delivered by the comic characters |
| Development | | |
| Comic Content Confirmation | • Positive reactions to story plot, especially that characters are transported into another world<br>• Specific suggestions provided about modifying age, hair and other physical features of certain characters | • Final comic plot: main character must battle an evil empire in an alternate world where healthy food is scarce.<br>• Suggestions were incorporated into design of characters (e.g., added spiked hair, incorporated glasses) |
| Comic & Web-based Tool Content Confirmation | • Email addresses not checked often; smartphone used often to text friends/family<br>• Grandmothers mentioned as positive family role model who gives advice to their grandchildren<br>• Preferred limited to no parental communication in intervention tool<br>• Bodegas often frequented where children may question a friend's purchasing/consumption of unhealthy snacks | • Choices to receive reminder messages from tool via email and/or text were incorporated<br>• Grandmother character who shares healthy food with people in need was incorporated into storyline<br>• Parental communication portal was not incorporated into final tool<br>• Bodega scenario incorporated into story where one character expresses discontent of another character's unhealthy food choices |
| Comic Assessment & Web-based Tool Development | • Positive responses to both chapter 1 (print) and chapter 2 (digital)<br>• Suggestions were provided to change spelling or phrasing of certain dialogue<br>• Wanted an easy log-in process<br>• Wanted a character image on home page to welcome user back<br>• Disliked proposed NYC subway theme as homepage wallpaper<br>• Wanted positive and encouraging feedback if goal not achieved, and preferred brief messages | • Remaining chapters were developed to be consistent with chapters 1 and 2<br>• Incorporated to more linguistically align with intended population<br>• Log-in required no special characters<br>• Welcome message from main character is displayed on home page<br>• Replaced with simpler homepage design with multiple component links<br>• Developed simple and short encouraging feedback for goal self-assessments |
| Usability Testing | • Several programming bugs interrupted flow of reading through chapter<br>• Clickable features in comic chapter were overlooked<br>• Clickable features in comic chapters were still overlooked<br>• Option to 'swipe' pages (instead of using arrow buttons) was overlooked and not utilized | • Programming bugs addressed to optimize user experience<br>• Clickable features icons were modified (e.g. color, shape)<br>• Clickable features icons were further modified (e.g. pop-out/button effect)<br>• Navigation guide added on how to 'swipe' page and identify/use clickable icons |

| Table 5: Summary of key findings from study sessions with parent participants and applications to web-based tool development | | |
|---|---|---|
| **Phase** | **Key Findings** | **Application to Web-Based Parent Tool** |
| Formative | | |
| Technology, Dietary Behaviors, and Health Promotion | • Most used devices were smartphones and desktop/laptop computers<br>• Preferred devices to read or look up information were tablets or laptops/computers<br>• Preferred reading platforms were books or PDFs of printed content<br>• Dietary behavior perceived to be most important was eating fruits/vegetables<br>• Common barriers to healthy eating were limited time and energy to cook and high cost of healthy food<br>• Learned health-related topics by looking up health information and recipes online, viewing videos on YouTube, or reading materials from child's school/after-school program<br>• Preferred health promotion tool that is family-friendly, has recipes, health-related tips and discounts/coupons, and is easy to use and engaging | • Ensure parent newsletter is accessible across different sized devices<br>• Make newsletter printable as a PDF<br>• Focus health content of newsletter on increasing fruits/vegetables<br>• Newsletter should include simple and cost-effective recipes<br>• Mobile devices are acceptable platforms for health information-seeking<br>• Newsletter should be developed to include these content and design preferences |
| Development | | |
| Content Prioritization | • Mixed format preferences for emailed newsletter vs. newsletter link sent as text message<br>• Disliked automated/impersonal text/email messages, and not knowing who messages were from or whether a link is "real"<br>• Preferred purchasing food from Costco, Target and Aldi's as preferred food store<br>• Habit to buy unhealthy snacks or takeout food for children<br>• Preferred the "instrumental", "conditional" and "gain frame" parenting approach | • Provide option for newsletter link to be sent via text or email<br>• Indicate in message who the sender is and provide full link URL to make its origin obvious<br>• Informed newsletter coupon choices and gift card choices (for future intervention compensation)<br>• Incorporate healthy snack preparation in parent tips<br>• Directly influenced parent-focused content related to healthy eating and feeding tips |
| Tool Development | • Messages with newsletter link needs to be sent from trusted senders<br>• Overall liked the clear layout of the newsletter, as well as the use of bright, vibrant colors<br>• Reacted positively towards motivational, instrumental, and gamification approaches, and negatively to regulatory approach<br>• Wanted coupons to places where they frequently purchase food from<br>• Preferred a link to more information about healthy events vs. placing too much text on the newsletter | • Messages need to include the name/source of the newsletter<br>• Confirmed design of the newsletter<br>• Confirmed tips for parent/child social interactions around health eating<br>• Confirmed coupon types<br>• Newsletter should only include brief description of the event and provide a link to more details |
| Usability Testing | • Liked use of bright, vibrant colors<br>• Felt the feeding tips and recipes were doable<br>• Notes recipe ingredients and directions may not be clear for all types of Spanish-speakers<br>• Did not notice text indicating the option to print the recipe<br>• Unclear that user needs to click the coupon section and healthy community event section to access it or get more information | • Confirmed design of the newsletter<br>• Confirmed tips and recipes content<br>• Use more common Spanish words for recipe ingredients and directions<br>• Make text to print recipe larger/darker and add a printer icon/button to make click action clear<br>• Add an icon/button to indicate the event and resources sections are clickable |

# Aim 3 (Evaluation Phase)

## Participants

Recruitment occurred between August and November 2017. We aimed to enroll a total sample size of 82 dyads, but through extensive recruitment activities, we successfully enrolled a total of 89 dyads (completed a T1 visit and were randomized to the experimental (E: n=45) or comparison (C: n=44) group. Participants learned about the study through: community events (39%), community flyering (34%), friend/referral (15%), or a community clinic partner (12%). Baseline (T1) child demographics were: mean age=10.4±1.0 years; 61% female; 62% Black, 42% Latino; and 51% overweight/obese. Parent demographics included: mean age=30.8±8.9 years; 94% female; 55% Black, 45% Latino; and 33% annual household income <$20,000.

## Principal Findings & Outcomes

**Recruitment and Retention.** While we estimated a 20% attrition rate, we had successful completion rates as: among child participants, 322 out of 356 total time points were collected (90.4% completion rate); among the parent participants, 245 out of 267 total time points were completed (91.8% completion rate). Average duration of data collection included: 22 min for child surveys (T1, T4); 16 min for child interviews (T2, T3); 11 min for parent surveys (T1, T4); 18 min for parent interviews (T3); and 65 min total per session. Parents at T4 (n=76) felt they received enough study information (97%) and that their questions were answered properly (80%). Eighty-one percent of children at T4 (n=75) were very /extremely satisfied with how study staff communicated and interacted with them.

**Outcomes.** Highlighted below are preliminary analyses for both primary measures and secondary outcomes measures.

*Child usability and acceptability (primary measure).* Mean overall usability survey score (5-point Likert scale) was 4.0±.37 for the E group and 3.8±.51 for the C group. In interviews, children reported finding automated reminder messages helpful, with few noting access issues. Most reported using the web platform at least once per week, typically at home. For the E group, nearly all had a positive response to comic content and could recall storyline details and characters. Most children reported selecting weekly goals. Some found it challenging to work on them or asked their parent for help. In the C group, children rated recipes and games as favorite elements.

*Child usage (primary measure).* The E group accessed the website more frequently than the C group over the 6-week intervention period (E=7.8±5.1 days vs C=5.8±4.2 days, 95% CI:0.046-4.0). Though not statistically significant, the percentage who accessed the website at least weekly was consistently higher in the E group vs. C group (5-19% greater by week). There were no statistically significant differences in the number of goals chosen or evaluated between groups by week; overall goal selection ranged from 27-69% for the E group and 27-82% for the C group.

*Child dietary-related outcomes (secondary measures).* Both E and C groups reported a significant increase in nutrition/health knowledge, outcome expectancies related to F/V intake, and self-efficacy related to vegetable intake, between T1 and T3 ($p<0.05$). Small differences were observed between the groups from T1 to T2 for self-efficacy related to vegetable (E=0.53±1.15; C=0.28±0.88, d=0.24) and water intake (E=0.23±0.90; C=-0.03±0.75, d=0.31), however, the between-group effects diminished at T3 for both vegetable (E=0.50±1.03; C=0.34±0.89, d=0.16) and water intake (E=0.31±1.00; C=0.12±0.95, d=0.19). The E group demonstrated greater improvements from T1 to T3 ($p<0.05$) in vegetable (d=.54 vs. d=-.15), water (d=.55 vs. d=.05), and sugar (d=-.37

vs. d=.07) intake. At T4, there were no significant differences in BMI changes between groups (E=0.15 kg/m2, C=0.18 kg/m2; p=0.94).

*Parental outcomes (secondary measures).* While parents in both groups reported improvements in feeding practices related to teaching, instrumental, and child involvement, they were only significant in the C group (p<.05). In both groups, there were no significant changes in healthy food availability or accessibility from T1 to T2. Though not statistically significant, weekly website usage was slightly higher in the E vs. C group across the 6 weeks. Mean overall usability score was high in both groups, but did not differ significantly. Parents responded positively to the newsletters, describing it as easy-to-use, informational, and motivating. Most found the feeding tips and recipes useful and tried a few with their children. While they liked the concept, most parents did not use the coupons usually because they were not interested in the featured item. While most parents did not attend the community events due to scheduling conflicts or the location, they liked the concept since events were low-cost/free and family-friendly. With E group parents, most reported viewing at least one comic chapter and highlighted their child's positive responses to the comic.

## Limitations

This pilot study has limitations, which need to be considered. Initial recruitment challenges led to modifications in BMI eligibility criteria. In addition to overweight/obese children, healthy weight children were also recruited. Not only could changes in BMI criteria dilute any anthropometric changes, but such recruitment challenges will also have implications for a larger scale randomized trial. Participants were recruited on a rolling basis over the course of three months, therefore, seasonality may bias various health-related behaviors, and thus our findings. The comparison group (both child and parent) received one less text/email weekly reminder compared to the experimental group, which may influence usage of the web-based tool, though this is likely to have a minimal impact, if at all. Self-reported data from both the children and parents were collected, which poses a validity risk, due to intentional/unintentional misreporting. However, our study design allowed for children and parents to complete surveys at home as opposed to at the study site with research staff, which may contribute to decreased social desirability bias. Finally, study findings have limited generalizability as the study was conducted in urban, low-income communities in NYC with Black/AA and Latino children and parents.

# Discussion

As childhood obesity rates continue to remain high, culturally appropriate interventions are needed to engage children and their parents. To the best of our knowledge, this is one of the first studies to document the integration of systematic planning, formative research, and iterative design processes, including active user involvement of minority children at risk for obesity and their parents, during the design and development process of a web-based health promotion tool. We ultimately produced a culturally-relevant, theory-guided interactive web-based comic tool with an engaging narrative and relatable characters that aims to reduce childhood obesity risk in urban Latino and Black/AA children. We also produced parental newsletters with relevant and meaningful content that promotes positive parental feeding practices and a supportive home food environment. Health content in the comic is delivered utilizing a combination of interactive/non-interactive features. This multi-media approach incorporating character voice-overs, pop-ups with health-related facts, and audio/visual special effects not only increases potential engagement, but can also help address health literacy issues and promote increased understanding of health messaging within at-risk populations

(30,31) We also designed a goal-setting/self-assessment component, which is a key construct in multiple behavior change theories (32) and often utilized in obesity prevention and weight management interventions with youth (33,34). Additionally, the individual tailoring of health messages based on initial screening questions allows for targeted content in the comic and parental newsletters to meet prioritized needs.

Of note, we successfully recruited and retained a population that is historically difficult to reach and engage. The retention rate for our 4.5-month study was high as we had a 90-91% survey completion rate for the entire study. Using multiple recruitment and retention strategies documented in the literature, along with continual improvement strategies that were applied throughout our study, we were able to sustain engagement and participation of low-income Black/AA and Latino children and parents. The lessons learned through this study will be applied in future studies and could be adapted for other community-based work.

While further analyses of the outcome data are certainly warranted, preliminary analyses of Aim 3 outcome data appear promising as children who read the comic demonstrated significantly greater improvements in vegetable, water, and sugar intake, from pre- to post-test. In addition, related psycho-social variables such as self-efficacy towards fruits, vegetables and water and attitudes towards vegetables improved in the E group compared to the C group. Our findings are supported in the existing literature, which highlights the potential benefit of entertainment-education in promoting health behaviors. Branscum et al. (35) found that F/V consumption increased significantly in children who were involved in creating their own comics. Similarly, Baranowksi et al (17) reported that entertainment-education, in the form of video games, also resulted in an increase in F/V intake. However, our intervention combined a narrative comic with interactive technology-enhanced components, along with individually tailored messaging. Future analyses should consider exploring dosage response patterns to better understand the ideal intensity and dose of such an intervention to lead to meaningful and sustainable changes.

## Significance & Implications

In this study, we successfully addressed gaps in the literature and generated new knowledge related to multiple research areas of interest for AHRQ, including design, development, usability and use of health IT, for culturally diverse and hard-to-reach populations. Additionally, this study targeted the understudied yet critical developmental stage of preadolescence.

Technology-assisted interventions that incorporate behavior change strategies and are developed with a human-centered approach have increased potential to expand reach and engagement, and can also be tailored to different populations. This study has contributed to the limited literature on the development of such tools by documenting the systematic approach we had taken to create an innovative, web-based tool with tailored health content promoting F/V and water consumption among urban minority children at risk of childhood obesity, as well as health promotion content focused on providing strategies and resources to improve parental feeding practices and the home food environment. This included the iterative usability testing approaches that we modified for our unique population. We have also presented findings from the pilot testing of this innovative web-based tool. Through a two-group randomized study, we found *Intervention INC* to be highly acceptable among children and parents. Furthermore, positive psycho-social and behavioral changes related to diet were observed among children in the E group compared to the C group. However, further testing will need to be conducted with a larger scale study.

# Conclusions

By incorporating user-centered methods throughout the formative and development phases, the needs, priorities, and preferences of the intended audience of this tool were able to be voiced through our study participants and integrated into the tool content and user interface design. While such methods consume time/resources, utilizing these approaches increases a tool's potential use and effectiveness, in addition to ensuring its cultural relevance. As preliminary results are promising and feasibility and acceptability of the tool was confirmed, we will pursue the development of a full-scale randomized controlled trial (RCT) to test the tool's effectiveness. Furthermore, dissemination, implementation, and integration of the tool into a community-based healthcare system can be explored in future studies. If found to be effective, the web-based tool can be translated into a publicly available online health tool, which could be disseminated widely and integrated into various settings such as clinics, schools, and community based organizations, highlighting its potential for broad reach.

# List of Publications and Products

**Publications based on Aim 1 (Formative Phase) and Aim 2 (Development Phase) data**
- Leung MM, Huang E, Killie N, Mateo KF, Bucci J, Fuster-Rivera M. Social Influences on dietary behaviors of low-income, urban Latino and African-American/Black pre-adolescents: Perspectives from Youth and Parents. Journal of Racial and Ethnic Health Disparities. [under review]
- Leung MM, Mateo KF, Verdaguer S, Hoyt K, Wong B, Bucci J, Dennis T. Design and development of a web-based interactive comic tool to reduce childhood obesity risk in urban minority youth. Journal of Health Communication. [under review]
- Mateo KF, Verdaguer S, Fuqua A, Hoyt K, Bucci J, Leung MM. User-Centered Design and Development of a Web-based Tool to Support Healthy Feeding Behaviors by Parents of Urban Minority Youth. JMIR Pediatrics and Parenting. [under review]

**Publications based on Aim 2 (Development Phase) data**
- Verdaguer S, Mateo KF, Wyka K, Dennis-Tiwary TA, Leung MM. A Web-Based Interactive Tool to Reduce Childhood Obesity Risk in Urban Minority Youth: Usability Testing Study. JMIR Form Res. 2018;2(2):e21

**Publications based on Aim 3 (Evaluation Phase) data**
- Leung MM, Mateo KF, Verdaguer S, Wyka K. Testing a Web-Based Interactive Comic Tool to Decrease Obesity Risk Among Minority Preadolescents: Protocol for a Pilot Randomized Control Trial. JMIR Res Protoc. 2018;7(11):e10682.
- DeFrank G, Singh S, Harrison L, Mateo KF, Leung MM. Key recruitment and retention strategies for a pilot web-based intervention to decrease obesity risk among minority youth. [in preparation]
- Additional manuscripts reporting on primary and secondary measures are currently in preparation.

**Product**
- 6-chapter interactive health promotion comic tool (with tailored health messaging and goal setting/assessment component)
  - https://incinc.org/

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